COMMENTS ON THE CCRP

Proposal to add Grazing Management as a Best Management Practice (BMP) for *Invasive Species and Wildfire in* CCRP Contracts

The Best Management Practice (BMP) is to allow grazing after the growing season every third year to control and prevent the spread of invasive species in the watershed. Several reports have been written proving that the use of large numbers of livestock for a controlled period of time has been an effective practice for the control of non-desirable plants. Many reports have also shown that when grass is not harvested to remove old growth the plant loses vigor, weaken and not reproduce normally. The old plant residue shades the new growth and weakens it so that it can easily be replaced by invasive or undesirable plants. Seeds of these noxious plants then are flushed downstream during flood events and spring run-off contaminating stream banks and rangeland lower in the watershed.

The use of livestock as an accepted BMP can help prevent this from accruing by removing old growth, breaking up soil crust there by improving the environment for new grass growth. The removal of the old growth will also reduce the risk of wildfire using the stream bank as a corridor. Many of the buffer areas along Wyoming's watersheds are not easily accessible for mechanical or chemical practices to control the spread of invasive plants and firefighting equipment.

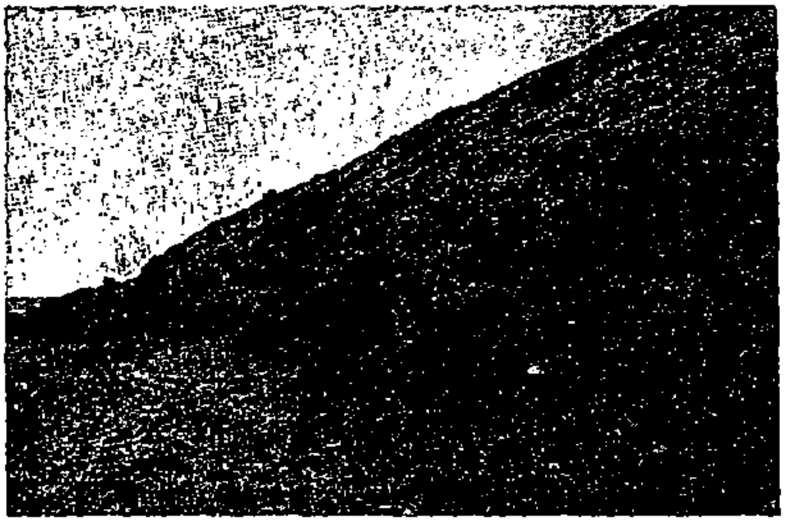
Using BMP's to control the time and timing of the grazing by livestock has been proven not only to be an effective tool in managing both of these problems, but wildlife habitat has been improved for many species. Sage Grouse especially have benefited as forbs are stimulated to increase in count and production of tender fall re-growth, that Sage Grouse require in the fall to survive the coming winter.

The Saratoga-Encampment-Rawlins Conservation District believes that the CCRP is very important to the recovery of many of Wyoming's Watersheds and riparian areas to ensure wildlife habitat improvement and protection. But without a management plan that controls invasive plants and stimulates and protects desirable plant health the program will not become the successful and beneficial tool needed for the protection of watershed health and wildlife habitat that are the program's goals

Another very good reason for considering controlled grazing as a BMP is to take a close look at many of our National Parks. In many of the National Parks invasive species have completely taken over ,changing the ecosystem by, decreasing or eliminating wildlife habitat and, most or all of the native plants. Congress is now starting to address their problem, Would it not be better to fix the problem now by installing preventive BMP's than fight a larger battle in the near future?.

Thank you,

Larry Bentley
District Coordinator Saratoga-Encampment_Rawlins Conservation District
P.O. Box 633
Saratoga, Wyoming 82331
(307) 326-8156
e-mail larry.bentley@wy.nacdnet.net



Revegetated slope at Cuba mine site, after first year of reclamation: an example of the use of animal impact for restoration. (Photo courtesy of Courtney White.)

chapter.) It produces enough food to support growth in the roots and the leaves, as well as to develop tillers and/or seed stalks. It stores up energy for the upcoming dormant season. It flowers and sets seed. Eventually the plant returns to dormancy, its leaves again turning brown. The health or vigor of the plant depends on its ability to produce enough food during the growing season to survive through the dormant season and resume growth when conditions are again favorable.

Grazing is a Disturbance that Grasses Tolerate

Grazing removes biomass from individual plants, one plant at a time. In extreme conditions, a grazing animal may remove nearly all of the plant's above-ground growth, but normally this does not occur. Cattle can barely graze closer than an inch or two to the ground because of the shape of their mouths, and they will not defoliate a plant completely unless there is no other feed available. The majority of plant biomass in grasslands is actually below ground, completely beyond the reach of grazers.

Grasses have several traits that enable them to tolerate grazing, and in some circumstances to benefit from it *[19]*. Most importantly, they produce more leaf area than is necessary for optimal photosynthesis, meaning that some leaf area can be removed without damage to their growth and reproduction. Younger leaves photosynthesize more efficiently than older ones, and defoliation of older leaves can expose younger leaves to greater sunlight. Many grasses have growth points very close to ground level, where they are unlikely to be bitten off by large-mouthed grazers like cattle. Grasses are adapted to fire in a similar way: all the plant parts needed for resprouting and surviving a fire are at or below ground level, protected from flames and heat.

These traits do not control the effects of grazing on a plant, however *[17]*. Grazing disturbs the plant by removing leaf tissue. This can be good, bad, or indifferent for the plant as a whole, depending on when the disturbance occurs (timing), how severe it is (intensity), and whether the plant is disturbed again (frequency). If very little leaf is removed, the effects of grazing may be negligible. A more severe, single grazing may slow growth in the

Misunderstandings About Utilization Rates

Utilization rates seem straightforward enough: They measure the percentage of above-ground biomass harvested by livestock. The old rule of thumb was "take half, leave half," which would mean a utilization rate of fifty percent—right?

Not necessarily. Properly understood, utilization rates measure the percentage of use of *annual* herbage production. If a pasture is grazed year-around, then "take half, leave half" is fifty percent utilization. But if grazing occurs only in the dormant season, or stops before the end of the growing season, "take half, leave half" is less than fifty percent. Why? Because the grasses grow back when given growing-season rest. Indeed, they may grow back almost completely, such that "take half, leave half" could mean almost zero percent utilization. In short, utilization rates can only be measured at the *end* of the growing season.

The limitations of utilization rates for grazing management are discussed in Chapter Five. Here, a couple of practical problems should be mentioned. First, managing for a particular utilization rate is always attended by a measure of uncertainty, because no one can know precisely how much longer the grasses will have sufficient energy and moisture to grow. An early frost or a dry late summer might result in an unexpectedly high rate of utilization by curtailing recovery, even in the absence of further grazing. This kind of uncertainty can easily cause problems between a rancher and agency officials. They may agree to a target utilization rate, but then find themselves at odds at mid-summer, if it looks like the target has been reached. Will continued growth balance out further grazing, or not? It's hard to say until later, by which time it may be too late.

Second, wildlife managers have embraced utilization rates for another reason: to ensure that sufficient cover is maintained for quail or other species that live, feed, or breed on the ground. Wildlife managers may not understand the temporal dimension of utilization rates, or at least they may define utilization differently than range scientists do. The miscommunication that ensues may lead to frustration and distrust. So if you do decide to manage for some rate of utilization, be sure that you and everyone else are clear about how and when it will be measured.

roots, and/or accelerate the growth of leaves, but recovery is likely if grazing does not recur for one to two growing seasons. Repeated defoliations in the same growing season, however, can set the plant back for many years to come *[107]*. These effects also depend on the plant species in question.

Until recently, it was believed that grazing caused grasses to direct energy stored in their roots up into leaf growth, just as occurs at the beginning of the growing season. More recent research suggests that this is not the case, although the precise mechanisms of recovery remain obscure. For now, the best conclusion available is that *the more leaf area that remains after grazing,*

Roger Bowe's herd concentrated on the Rafter F Ranch. (Photo courtesy of Roger Bowe.)

faster recovery occurs [16]. Obviously, recovery can only occur when the plant is growing; for most perennial forage species, active growth occurs for only a small portion of the year.

Timing, Intensity, Frequency

From this simple account of the growth of a single grass plant, it is clear that the effects of grazing vary tremendously. The principal factors are:

● **Timing**. Grazing during the dormant season is unlikely to affect the plant's prospects the following spring, because the animal is removing non-photosynthetic tissues. During the growing season, the effects of grazing can be more significant. If a plant is grazed repeatedly in the early growing season, it may exhaust its energy without a chance to recover. Severe grazing just before seed is set can also be very harmful. Evaluating grazing impacts and recovery during the growing season requires close monitoring of key forage species. Once a plant has set seed, its growth for the season is largely complete.

● **Intensity**. The more leaf area that is removed, the more slowly the plant will be able to recover. How much leaf area is removed depends on grazing pressure: how many animals are present, of what kind, and for how long.

● **Frequency**. A plant that is grazed multiple times during a single season must recommence recovery each time, and will suffer compared to plants grazed only once or twice. Full recovery includes both above- and below-ground growth. Plants that are grazed too frequently will eventually have less root mass, and produce correspondingly less leaf tissue. This leaves them more susceptible to damage from drought or other subsequent disturbance.

Whether plants recover from grazing also depends on larger climatic conditions, of course. During severe drought, water may become so limiting that plants are unable to grow, meaning that recovery from grazing is effectively impossible. Long-term research conducted on the Jornada Experimental Range near Las Cruces, New Mexico, found that the severe drought of the 1950s largely eliminated black grama grass, even in areas where no grazing occurred. (In

Overgrazing and Overrest

Overgrazing occurs when a severely grazed plant does not have time to recover before being grazed again. A plant that is grazed once or twice, then allowed to rest for the remainder of the growing season, is very likely to recover completely. If it is grazed repeatedly, it will have less time and reduced resources for recovery. The health of the plant depends on both its leaves and its roots, and an overgrazed plant tends to have shallower roots, weakening its ability to recover from subsequent grazing events or to withstand other disturbances such as drought. A downward spiral can result: less forage for cows, who then impact each plant more severely, leading to still less forage, and so on. Livestock, plants, soils, watersheds, wildlife, and ranchers all suffer when overgrazing occurs.

Note that the critical issue is *time.* The number of cattle in a pasture is important, too, but only because higher stocking rates make it less likely that a grazed plant will have time to recover. Lower stocking rates make it more likely. Moreover, what makes for overgrazing changes from year to year and season to season. In a good year, with more moisture, plants recover more quickly; in a drought they recover slowly. So even a lightly stocked pasture may be overgrazed in a very dry year, whereas a heavily stocked one might not experience overgrazing in a very wet year. This is why ranchers like Jim Winder and Roger Bowe (see **The Beck Land and Cattle Company,** p. 59 and **The Rafter F Cattle Company**, p. 45) speed up their rotations in wetter years and slow them down in dry years. *Control of timing is critical to avoid overgrazing.*

Kirk Gadzia indicates the space between perennial plants on grazed land (above) and ungrazed land (below). These areas are about fifteen yards apart. The ungrazed land has not been used in forty years. (Photos courtesy of Courtney White.)

Overrest is, for certain grass species at least, the opposite of overgrazing. It occurs when disturbance is absent for such a long time that the accumulated growth of past years prevents the plants from cycling enough energy to remain vital. The old leaves give the plants a gray tone; they shade out areas where new plants could otherwise germinate; root systems slowly contract. (See photo on p. 4.) Overrest can occur even in the presence of livestock, since decadent plants are not palatable and may be avoided.

In the long run, overrested areas are prone to a fate similar to overgrazed ones. Eventually, some disturbance will occur—a drought or a fire, for instance—and the weakened plants may be unable to recover, leading to more bare soil, erosion, etc. (The same risk attends forests where fire has been suppressed for too long.) In ecosystems adapted to disturbance, managers must negotiate carefully between overgrazing and overrest.

Restoring Riparian Areas

Controlling the timing, intensity, and frequency of grazing is important on all rangelands, but the results of management are most apparent in riparian areas, where water and nutrients are more abundant than in the surrounding uplands. Jim Winder's Macho Creek is but one of numerous examples of riparian restoration through better control of grazing. (See photos on p. 56.)

Under continuous, year-round grazing, cattle tended to overutilize the riparian area, where forage, water, and shade were relatively abundant. As a result, plants were grazed repeatedly, with little time to rest. Over time, Macho Creek became little more than a depression in the range. During floods—as in the photo—the water was muddy with sediment. At other times, the creek was completely dry.

Jim's cattle still graze Macho Creek, but the timing of the grazing has been carefully controlled for the last fourteen years. Grazing occurs mostly in the dormant season, and only for very short periods of time, giving the plants ample time to recover. The resulting change has been dramatic, as the photos illustrate. Riparian trees have established and grown, and the creek has returned to clear, perennial flow. Forage production has also increased. In fact, Jim's cattle harvest ten times as much forage from Macho Creek than before, but with far less impact on the plants. Just upstream, where a similar management change has been implemented in a collaborative effort by the permittee, the State Land Office, the Quivira Coalition, the Jornada Experimental Range, and HawksAloft, monitoring has documented increases in both forage and songbird abundance and diversity.

These results are not exceptional. On Date Creek, in Arizona, rancher Phil Knight has restored an amazing cottonwood-willow forest (see photo above) simply by limiting grazing to the winter, dormant season. (Before photo on left. [Photos courtesy of Dan Dagget.]) There are other examples from elsewhere in the Southwest *[15]* and the arid and semiarid West *[33, 64]*. Riparian areas in arid and semiarid regions are extremely important for wildlife, watershed functioning, and forage production. Fortunately, they can restore themselves fairly quickly given greater control over the timing, intensity, and frequency of grazing.

6. MANAGEMENT OF RANGELAND WATERSHEDS WHICH DIRECTLY AFFECTS WATER QUALITY

We now look at how range watersheds are influenced by management and how management actions may have different kinds or levels of impacts on the intended results. At the conclusion of this part, we recommend that you read an excellent article reprinted in Appendix IV (Prescription Grazing to Enhance Range Watersheds). Although all rangeland watersheds will not be grazed by domestic livestock, a high probability exists that most will be grazed. Therefore, we will assume that livestock grazing is the primary use which must be managed. We will further assume that vegetation on the watershed(s) is the primary component which has the potential to affect capture, storage, and beneficial release of moisture. A project would not (probably) even be considered unless the sponsors thought that the watershed function was not operating satisfactorily and that something "wrong" could be righted through a change in management.

Books have been written, based upon research, which examine in great detail how grazing and other range disturbances influence site conditions. Users of this document are encouraged to read and understand that material if they need to know more. The purpose of this part of the primer is only to look at the characteristics of grazing and other disturbances in relation to the effects on vegetation and thus on watershed function.

Any project sponsor, when it comes down to it, must ask what desired changes do we want in relation to the goal of improving watershed function? The changes may be couched in any number of different forms, e.g. desired future condition, potential plant community, or simply, a certain level of vegetation change which more adequately utilizes the site's resources. Riparian zones are an important component and even though they make up only .5 to 2% of western watersheds, their importance lies in the storage and safe release component much more than in the capture part of the function. Aside from watershed function, riparian zones can provide 80% or more of the habitat for many species of wildlife.

For water to be stored, and then beneficially released, there must be soil depth and therefore volume. Many low gradient stream channels and their associated riparian areas can be improved by managing for sediment deposition. Taller vegetation of diverse structure (a mix of herbs, shrubs, and trees) will allow this to develop. If one's objective were to manage for a higher population of those types of species, the monitoring approach would need somehow to be able to discern that.

Desirable vegetation needs the opportunity to grow and reproduce itself. Invariably, desirable vegetation is perennial, not annual or biennial. A possible exception to this would be the California annual type where virtually all the herbaceous species on upland have been annuals for much of the past 1 1/2 to 2 centuries. New plants may not be necessary each year but the opportunity for the plant to reproduce itself needs to be provided whether or not that is the result. The age-class structure of healthy vegetation needs to be understood. As an example, there are innumerable places in the western U.S. along water courses, or in snowdrift accumulation areas, where species such as aspen, cottonwood, and willow are present primarily as mature and old specimens, or may even be absent since they were removed by past management practices. Where are the young and middle-aged plants, which by definition are necessary to sustain those kinds of plant communities? Managers need to develop actions which will accomplish that, if that is possible. For example, water diversions or impoundments to accommodate irrigation or other beneficial uses may have altered the stream flow so that new ecological potentials exist.

A significant proportion of western U.S. vegetation developed with fire as part of its environment. That influence has all but disappeared although much academic and some management attention is being given to prescribed burning. Some species on uplands, especially woody shrubs and trees (e.g., species of sagebrush and juniper) have greatly increased their area in the absence of fire. Plants such as these two categories, when in overabundance, strongly influence the capture and storage functions. Research shows that moisture is lost to the site by overabundance of these species through their competitive effect on desirable plants rendering many interspaces bare or nearly bare. The moisture that does enter the soil tends to be entirely used by the abundant woody plants leaving none for deep percolation (storage) and release to streams.

Often, management actions cannot use prescribed fire in the first phase because too much fuel exists or there is not enough fuel or because it is standing (trees or tall shrubs) and not prone to burn. Some other form of vegetation manipulation would be in order since research and experience shows that managed grazing in those circumstances can't be successful in beneficially changing the vegetation in a reasonable time frame. There are exceptions to that statement (e.g., goats do consume small junipers; feeding cows in winter physically breaks sagebrush). However, managed grazing is more effective when animals will consume undesirable as well as desirable plants or plant material, or, in some cases, when undesirable plant changes have not progressed too far and a combination of managed grazing and some direct intervention will be successful in tipping the balance in favor of desirable species.

What about the grazing activity itself as a manipulative tool for vegetation? Vegetation often is perceived <u>only</u> as forage for animals and not critically important to the adequate functioning of the watershed. We need to realize vegetation's role for all of its properties. Sometimes a concerted educational program and coordinated resource management planning, where we can come to common understanding of the problems and develop acceptable and workable solutions, is the first part of a successful watershed project.

How understanding comes about is outside the scope of the primer. But, for grazing livestock to be managed in accordance to a watershed goal, some change in relation to current procedures probably is necessary. Much research has gone into trying to understand how animals graze and their effects on plants. A whole body of knowledge has developed on grazing management to show how livestock and plant species interact. It is a complicated subject with endless combinations of management factors. Managers with a clear land objective(s) in mind can often accomplish desired vegetation objectives through using animals in some of the following ways:

- How many livestock, of which kind or class, should be grazed at any particular time during the year?

- How long should the livestock graze? How long should plants be rested? How do rest and graze periods affect the vegetation at different times of the growing season?

- How much vegetation should not be grazed (left as residual) in relation to time of a season? Grazing a pasture in the dormant season to (X) pounds per acre residual may be fine because it will all grow back when the growing season comes. Grazing it to (XXX) pounds per acre residual may be necessary in the mid-growing season in order for the desirable plants to have the opportunity to regain vigor and to complete their growth cycle.

- Where does one graze in relation to ecological sites available to graze?

- How does one get effective distribution of the grazing over the land (both stock and wildlife)? How does it change during the year? Do wildlife numbers need some control?

- Should one graze more than one kind or class of stock in order to meet certain objectives?

These are only some of the considerations. Commonly, grazing approaches will change over time as conditions change. Strongly consider the safety valve of not utilizing any area too heavily at any time until provisions can be made to closely manage and monitor all aspects of the program and to plan far in advance of actual livestock moves.

Be realistic in your expectations of change both in terms of how much and how fast. Vegetation in riparian areas will change more rapidly and to a greater extent than that on uplands. Drought, or below normal moisture, will make change especially slow on uplands, even when the management is correct for the site conditions.

Always keep the vegetative objectives in mind. The vegetation objective for each ecological site should have been constructed to achieve something to do with capturing, storing, and safely releasing water in the watershed. As stated earlier, unless there is something unusual in the soils, geology, or other uses, the physical, chemical, and biological effects on water quality will be benefited when the watershed is in proper functioning condition.

Because there are so many real possibilities, examples are considered of little importance. This is not a cop-out; we simply do not want readers to grasp an example as something they can directly apply to their own situation. Because we have assumed that most range watersheds will be grazed by livestock and probably wildlife as well, we strongly recommend that watershed project sponsors gain technical assistance on vegetation and grazing management from qualified professionals. We must remember that domestic stock are owned and managed on a private enterprise basis. Each ranch operator has objectives, not all of which may fit the watershed objectives at the outset. Ways need to be found which dovetail various objectives, including those that relate to wildlife and fish and other kinds of uses.

The approach of coordinating the resource management through a recognized process called Coordinated Resource Management Planning (CRMP) would serve project sponsors and managers well. The Society for Range Management recently (1993) published a comprehensive set of guidelines on Coordinated Resource Management. Specific articles on how to conduct coordinated resource management planning are included in Appendix V.

Prescription Grazing to Enhance Rangeland Watersheds

E. William Anderson

Water is the most precious commodity derived from our rangelands and forests. All these lands should be managed primarily as watersheds and secondarily for their food, forage, wood, wildlife, social, and other products.

Watersheds vary greatly in their natural erosion and flood behavior. In some places plant cover and soil mantle have not developed sufficiently to exert much influence on the way water is yielded from the land. In these places, erosion, sedimentation and flooding is usually high. On more extensive areas, plant cover and soil mantle have developed to exert a high degree of control on the reception and disposition of precipitation. Low rates of erosion, normally moderate peak stream discharges, normally small sediment loads, and optimum infiltration are the result. The key lies in controlling the water that falls on each acre (Bailey 1950).

Depleted watersheds, for whatever reason, cause serious widespread and long-lasting second- and third-order consequences on-site and downstream, economically, and socially. These adversities are intensified under drought conditions.

Formulating prescribed grazing to enhance watershed dynamics requires diagnosis of elements involved.

General

Unpredictable cyclic droughts of varying intensity and longevity are normal occurrences. The old adage "an ounce of preventation is worth a pound of cure" applies to the timeliness of applying a grazing prescription. How grazing is done prior to drought is more important than what can be done effectively after drought has commenced.

The key to grazing that will enhance watershed dynamics is encompassed in the basic ingredients of watershed management, i.e., managing for water efficiency. These ingredients, which have been stated by Barrett (1990), are to CAPTURE, STORE, and SAFELY RELEASE water on watersheds.

Barrett's ingredients do not represent a new concept. Several relatively old studies are cited herein to emphasize that both early and more recent studies related to watershed management are prevalent. There is an urgent need to apply already available watershed management knowledge to the land as a basic ingredient of all renewable resource management.

The author is Certified Range Management Consultant, 1509 Hemlock, Lake Oswego, Oregon 97034 (503) 636-8017

Vegetation is only one factor of watershed dynamics. Others include:

— Surface geology	Soft to hard materials
— Soils	Texture, structure, depth, gravel/stone content
— Climate	Frequency, intensity, kind and duration of precipitation, frosts and thaws
— Runoff	High to low peak flows
— Topography	Steep to gentle slopes
— Land use	Intensive to extensive
— Upland erosion	Rills and gullies
— Channel erosion	Banks, bottoms, sediment load

Factors that are responsive to resource management measures are primarily vegetation and surface-soil structure. Depleted organic content, animal trampling and vehicular traffic are causes of soil-structure changes that can be improved over time by resource management. Other factors listed impose restrictions on the degree of feasible improvement that can be achieved through resource management.

The dynamics of woodland and forest watersheds involve vegetational features that are in addition to those related to rangeland watersheds, such as interception of precipitation and insulation from solar radiation caused by trees. The following discussion is focused on rangeland watersheds.

Capture

The role of vegetation in the capture of water on rangeland watersheds is influenced by certain factors which include vegetational type, stand density, size, degree of utilization, and uniformity of total vegetational cover, including residues.

The way *kind* of vegetation influences the capture of water is illustrated by a study that measured the effects of artificial moderate- and high-intensity rainfall on four vegetational types growing on coarse-grained granitic soils in Idaho (Craddock and Pearse, 1938). They reported that based on the general means of each vegetational type, a 35% density wheatgrass-type cover with its fibrous root system absorbed nearly all the water applied. A 25% density cheatgrass-type cover, which is quite dense for that type of vegetation, was moderately effective—75%—for capturing water. A 30% density lupine/needle-grass-

Side-by-side examples—separated by ownership fence and each grazed annually but under different systems—illustrating how a vigorous full stand of fibrous-rooted bunchgrasses provides superior cover, roots, and organic matter in the soil to capture, store and safely release water and create a sponge effect on the watershed.

type cover, which represents early stages of range deterioration at high elevations in the locality of the study, was of little value—50%—for capturing water. The annual weed-type cover with its single-stem tap rooted annuals was regarded only as an erosion hazard with 39% water capture.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to improve the proportion of perennial, fibrous-rooted bunchgrasses in the vegetation on the watershed.

Stand density of perennial grass species influences capture of water by physically impeding movement of the water. The greater the stand density of perennial grasses, the slower the water movement over the surface, giving it time to penetrate the soil. The reduced rate of over-the-surface flow also reduces loss of soil and fertility through erosion. This promotes increased vigor, seed production, seedling establishment and, subsequently, stand density.

On a watershed basis, the greater the stand density of perennial grasses, the greater the total amount of water funneled into the below-plant zone and captured.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to increase plant vigor. This, in turn, increases the probability and amount of viable seed production. It increases residue cover to benefit micro-environmental conditions necessary for seedling survival which will eventually thicken the stand of perennial grasses.

The way *size* of perennial grasses influences capture of water is illustrated by a study of how individual bunchgrass plants intercept precipitation and funnel water into the soil directly beneath the plant (Ndawula-Senyimba, Brink, and McLean, 1971).

They found that, with 1 inch of precipitation, penetration into bare soil was 4.7 inches. Under a bunchgrass closely clipped to simulate severe utilization, penetration also was 4.7 inches. Under bunchgrasses 12 inches, 16 inches, and 21 inches tall, penetration was 6.0 inches, 6.7 inches, and 7.8 inches, respectively.

This illustrates that water penetration is deeper, or at least more rapid, beneath bunches of grass than under bare soil or severe utilization. From a watershed standpoint, there is a direct relationship between size of grass cover—height and diameter—and depth of water penetration, e.g., volume of water intercepted.

The way *degree of forage utilization* influences capture of water is related to the amount of standing topgrowth left after grazing ceases and, on some soils, to soil compaction due to trampling.

A study of water infiltration as related to degree of utilization was conducted by Rauzi and Hansen (1966). They showed water intake on lightly grazed rangeland to be 2.5 tmes that on heavily grazed and 1.8 times that on moderately grazed rangeland.

A study of soil compaction by animals (Alderfer and Robinson 1947) showed that, in the top 0-1 inch layer, volume weights (bulk densities) were 1.09-1.51 under light grazing and were 1.54-1.92 under heavy grazing. As a soil is compacted, bulk density increases with a corresponding decrease in pore space. This reduces the capacity for storage of water that can percolate through the soil profile to feed plants, springs and streams.

This same study reported that, in the top 0-1 inch layer, non-capillary porosity—the pore space normally occupied by air—was 15% to 33% under light grazing and only 3%–10% under heavy grazing. Such disruption of the normal balance between air, water, organic, and mineral soil composition can be detrimental to biological activities, including plant growth.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to practice moderate utilization to maintain a stubble and residue cover. Rotating deferred grazing or rests among management units, as appropriate, avoids grazing the same management unit during the same season in consecutive years, especially during normal wet-soil seasons when soil compaction occurs most readily. Keeping livestock distributed and rotated as frequently as practical avoids localized trampling damage.

Uniformity of vegetational cover, including residues, influences capture of water on rangeland watersheds by minimizing the adverse effects of soil splash caused by impact of raindrops. Raindrops cause soil detachment, which is the first of two stages in the process of water erosion. Transportation of detached soil particles by flowing water is the second stage. Raindrop impact and the resulting soil splash seals the soil surface thereby reducing rate of water infiltration.

Osborn (1950) studied the effects of vegetational cover on reducing effects of soil splash. He reported:

—Uniformity of vegetational cover over the entire watershed is the most important requirement for preventing soil splash and sealing the soil surface. Water lost from certain spots, unless intercepted, is lost from the watershed.

—Effectiveness of the vegetational cover to reduce soil splash is related to the degree of coverage or density and its mass weight or height.

—Best water infiltration occurs on rangeland in top ecological status and progressively declines as status declines. Soil conditions also influence water intake and loss, and these soil conditions are often related to the status of ecological development or deterioration of vegetational cover.

—Soil splash can be controlled on low ecological status rangelands provided surface residues are sufficient to intercept raindrops.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to improve the uniformity of vegetational cover and residues over the entire watershed so as to reduce soil splash and minimize spots from which water is lost.

From the standpoint of watershed dynamics, it should be quite apparent that degree of use of the range needs to be judged by the amount of soil-protecting cover remaining, rather than by the percentage of the current season's growth removed, as is too often the customary procedure (Anderson 1960; Anderson and Currier 1973).

Storage

Water is stored in soil in three forms: hygroscopic, capillary, and gravitational. *Hygroscopic* water is that portion of soil water that is held tightly adhered to individual soil grains. It has no movement as a liquid and is not available for biological functions, including plant growth. It is depleted by heat and, once lost, must be fully replaced before water enters other portions of the soil structure.

Capillary water is soil water in excess of the maximum held as hygroscopic water. It lies in the interstices between soil grains. It is in liquid condition but does not respond appreciably to gravity yet it is available for biological functions. When the maximum of both hygroscopic and capillary soil water is reached, this condition is called *maximum field capacity.*

Gravitational water is that soil water in excess of maximum field capacity. It is available for biological functions and is free to move through the soil air spaces to form seeps, springs and creeks. This movement is called *percolation* and it takes place only after the hygroscopic and capillary water storage capacity is attained.

There are many factors which affect storage of water in soil. Those related to soils include surface features such as a sandy mulch or pebble/stone pavement, which affect infiltration and evaporation; texture and stoniness, which affect water holding capacity; structure, which affects infiltration and percolation; and depth, which affects water holding capacity of the soil.

Of these soil factors, only surface characteristics can be influenced by resource management. For example, livestock trampling and vehicular traffic can cause surface compaction on some types of soil, thereby restricting infiltration. Erosion of soils with stony upper layers creates a stone pavement. As soil particles are removed, stones in the upper soil layers are exposed and added to those already on the surface thereby restricting infiltration. Surface stones also occupy space needed for reestablishing a vegetational cover.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to minimize impact on the soil surface by livestock and vehicles and to provide adequate vegetational cover to minimize soil splash and subsequent water erosion.

Once water has entered the soil profile, several vegetational factors affect its storage:

—The more height and cover of vegetation, the less water is lost by evaporation due to sun and wind.

—Conversely, the more the vegetational cover, the greater the soil-water loss through transpiration.

—Vegetational residues on the surface reduce water loss caused by evaporation.

—Organic content of the soil increases the amount of water stored in the soil, which enhances the sponge effect of the watershed.

How organic matter increases water storage in soils is illustrated in a study cited by Lyon and Buckman (1934) which compared the water holding capacity of two silt loam textured soils, one containing 1.6% organic matter, the other 4.9%. These soils had maximum field capacities of 39% and 48%, respectively. This represents an increase of 23% in water storage due to increased organic matter in the soil.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to increase the volume of roots in the soil profile as well as residues on the surface by improving plant vigor and stand density (Anderson 1951). This, in turn, will eventually optimize soil organic matter and humus in the topsoil.

Safe Release

Safe release of water from rangeland watersheds is needed to benefit on-site vegetation as well as streamflow via percolation.

Prolonging storage of water in the watershed—essentially creating a sponge effect—by reducing rate of deep percolation is an important factor. An optimum stand of vegetational cover utilizes a considerable portion of available soil water rather than allowing it to drain away from the site. For example, a study cited by Lyon and Buckman (1934) compared water loss through percolation from a bare plot versus a vegetated plot on the same soil series under 32 inches precipitation. The bare-soil plot lost 77% of the precipitation through percolation, whereas, the vegetated plot lost 58%.

Excessive percolation or drainage may be much more serious in robbing the soil of plant nutrients than depletion from use of nutrients by vegetation growing on the land. Table 1 illustrates how vegetational cover markedly reduces annual loss of nitrogen, calcium, and potassium by percolation.

Table 1. Average annual loss of nutrients by percolation from bare and cropped soils (from Lyon and Buckman 1934).

Soil	Annual Loss		
	Nitrogen	Calcium	Potassium
	(pounds per acre)		
Dunkirk — bare	69.0	398	72.0
rotation crops	7.8	230	57.7
grass continuously	2.5	260	61.8

Improving seeps, springs, and streamflow involves applying measures that will increase the volume of water captured in the total watershed. Uniformity of treatment over the total watershed is paramount if total volume of water is to be optimized. Water lost from certain spots, unless intercepted, is lost from the watershed.

Prescribed Grazing Strategy

Based on this diagnosis of major ingredients in the CAPTURE, STORE and SAFE RELEASE of water, a grazing strategy designed to enhance watershed dynamics should be based primarily on achieving improved efficiency in the ecosystem involved. Benefits to livestock production, wildlife, aesthetics, and others in the mix of desirable products will follow automatically.

The strategy should include:

—Moderate utilization of forage to build and retain an adequate cover of fibrous-rooted herbaceous species, residues, and soil organic matter.

—Rotation of deferred grazing and/or rests to build root systems and plant vigor to optimize vegetational cover, production and reproduction.

—Pre-conditioning, where appropriate, to benefit plant vigor and improve quality of mature forage for the benefit of wild and domestic grazing animals (Anderson et al. 1990).

—Management practices that will achieve grazing distribution for uniformity in vegetational cover on the watershed.

Intensity of applying this strategy must necessarily vary with the situation involved. In any case however, intensity of application must not exceed the capability of the resources nor the managerial ability of the manager. Otherwise, failure will be inevitable.

No-grazing Option

A logical question to ask regarding a grazing prescription designed to enhance watershed dynamics is whether no grazing at all might be the best prescription. In some instances, theoretically and for a relative short period of years, this may be the preferred option.

However, watershed management should be a long-term endeavor—actually unending—and be based on producing a mix of beneficial products, in addition to water, in perpetuity. Therefore, it is essential to consider other consequences that likely will be involved if the no-grazing option is chosen.

After a period of time, ungrazed herbaceous fibrous-rooted plant species become decadent or stagnant. Annual above-ground growth is markedly reduced in volume and height. Root systems likely respond the same. The result is reduction in essential features of vegetational cover, including the replacement of soil organic matter and surface residues, and optimum capture of precipitation. For example, an unpublished study by Anderson showed the green-leaf weight of a decadent bluebunch wheatgrass plant, which had been ungrazed for a number of years, to be 53% that of a nearby plant having equal basal area and being moderately grazed annually under a rotation of deferred grazing. Both plants at one time were in the same grazing unit until relocation of a highway right-of-way fence isolated one area. Each of the plants measured was typical of the stand of plants on its side of the fence.

Other consequences include (1) loss of quality herbaceous forage for wild herbivores, causing them to move to areas where regrowth following livestock grazing provides succulent forage (Anderson 1989), and (2) increased hazard from wildfires that can be devastating from a rangeland watershed standpoint.

Therefore, it is more realistic, from both a practical and technical standpoint, to employ a livestock grazing strategy that achieves and maintains a healthy, productive and biologically active vegetational cover on the watershed. This is essential for enhanced rangeland watershed dynamics.

References Cited

Alderfer, R.B., and R.R. Robinson. 1947. Runoff from pastures in relation to grazing intensity and soil compaction. J. Amer. Soc. Agron. 39:948-958

Combining herds and treating several cells as one cell gives land longer recovery periods and additional benefits from greater stock density. It may also help you maintain a constant level of nutrition, thus reducing the need for supplements.

so many animals. Many experienced people vow that all kinds of problems arise when numbers top 140 head.

Specialized breeding programs and other considerations may make separate herds necessary, but simple numbers usually don't. The doubters generally do not believe that animals can learn behavior that makes herd size almost irrelevant to the question of handling. In fact nobody has ever proved any upper limit, though no doubt every situation has one. If you do have the option of combining herds in a flexible way, consider now how you could use the nutrition available in standing forage more efficiently.

The Barlite Case

On the Barlite ranch near Marfa, Texas, managers Charles and Katie Guest faced reduction of the 1,200-head herd they had divided among seven cells, containing a total of 101 paddocks. They estimated their reserves and figured they could survive if each square yard of ground merely grew an additional half ounce of feed.

To maximize animal impact and minimize the risk of overgrazing, they put all 1,200 head together and moved them daily. This gave each paddock a maximum dose of dung, urine, and trampling, followed by 100 days of recovery.

"I didn't think anyone could move that many cattle every day," Charles Guest remarked later. "But they were so used to the fences already, they pretty well moved themselves."

Finally in October and November an inch and a half of drizzle blessed the Barlite. The Guests figure it grew them 21 million pounds of feed. The sudden lushness of their ground stopped abruptly at their boundary fence—beyond which their neighbors' cattle had grazed continuously at half the Barlite's stocking rate. While the neighbors continued to destock, the Guests bought 206 cow-calf pairs at distress prices and cut their supplemental feed bill by $26,000.

Herd Effect

Herd effect—the hoof action of excited animals on plants and soil—is perhaps your most powerful tool in managing succession in brittle environments. Whereas stock density, another key aspect of animal impact, is a mathematical relationship between the number of animals and the size of the grazing area, herd effect is only a matter of behavior. Theoretically a herd of any size can produce it on any piece of land. But:

The bigger the herd, the better the herd effect.

This is not a linear relationship. A herd of 1,000 can generate much more than 10 times the amount of herd effect produced by 100 head. Very small herds will not create much herd effect at all.

In biological planning, the idea is to anticipate the areas where you will apply herd effect for any number of purposes, including the following:

- To suppress brush directly by breaking it down
- To return stale, ungrazed plant material to the soil as litter
- To promote succession toward grassland or tighter spacing between plants

- To soften the banks of gullies and start succession in eroding areas or cropland being returned to pasture
- To reduce infestations of noxious weeds by direct impact and by creating soil conditions that favor fibrous-rooted grasses and sedges over tap-rooted species
- To clear firebreaks or roadsides

By withholding herd effect, you can promote brush in areas where you might want it for wildlife habitat, winter cover, and the like.

In the wild, predators account for a large degree of herd effect. In fact, game animals as well as domestic stock tend to become placid when free of that danger. Driving livestock with cracking whips or dogs obviously causes herd effect but at an unacceptable price in lost performance and handling qualities. Positive inducements, however, do not have these side effects.

For example:

- Supplements such as hay or cake fed on the ground will quickly excite any herd trained to expect a handout.
- Salt will gather a herd that has been denied it for some time. Granulated livestock salt, simply fed on the ground, works best.
- Diluted molasses sprayed on weeds or firebreak areas will stimulate both grazing and herd effect on specific locations.
- Static inducements such as salt blocks and liquid mineral licks do not produce herd effect. Animals visit them singly and tend to loiter. Putting mineral supplements on a trailer that can be moved from place to place works better but falls short of the ideal.

Training plays a large role in all these techniques. Animals that have never tasted molasses, for instance, will not recognize the smell and may ignore it at first. Livestock will quickly learn to come to a whistle, though, if it consistently means a treat. Such training not only helps in stimulating herd effect but also simplifies the business of moving stock to new paddocks or grazing areas. Holding back a few trained animals to mix in with untrained stock vastly speeds this training.

Multiple Herds

Although the land in a cell benefits most when livestock run in a single herd, many situations call for running two or more herds separately. You can do this in three ways:

- Assign several paddocks to each herd and plan each division as a subcell.
- Move separate herds among all paddocks while keeping recovery times adequate.
- Have one herd enter a paddock as another leaves ("follow-through grazing").

The planning procedure in the next section ("Creating Your Plan") tells how to compute grazing periods—but they may prove unacceptably long in cells with few or very unequal paddocks. Although follow-through grazing is particularly tricky to plan, it does fill certain needs best:

- When herds require different levels of nutrition (say, first-calf heifers and mature cows)
- When different types of livestock impact forage differently (goats following cows may use browse better)
- When topography or labor considerations favor keeping herds close together

The procedure on page 74 tells how to compute grazing periods for each herd on follow-through grazing. The diagram shown on the next page presents two cases. Equal paddocks cause no problem, though plants are exposed to animals for twice the grazing period of one

Chapter 5: Management Considerations

Introduction

A watershed and rangeland manger may be compared to being a chef in a restaurant. Both positions have a responsibility to satisfy customers and both follow recipes to achieve their goals and objectives. We all know that there are no "cook books" for riparian management, but this chapter will provide insight into the management of vegetation, grazing, stream flow augmentation, and developing water quality standards. These thoughts are not meant to replace the experience and ingenuity required to make sound management decisions. Instead, they attempt to convey important points to consider in developing successful management strategies to address Wyoming issues.

Vegetation

When the snow and cold leave Wyoming during spring, the land turns green from the stored soil water. In late spring and summer, Wyoming's green landscape gradually turns to yellow and then red when the stored soil water of fall and spring is depleted from the uplands. Riparian areas remain green from soil water provided by irrigation, springs, bogs, ponds, lakes, and streams during most of the growing season.

From a grazing management perspective, the colors green and yellow have meaning. Large grazing animals will selectively graze green plants, and avoid yellow or red plants. The yellow or red plants of summer and uplands have adjusted to growing where a limited water supply exists and, therefore, complete their growing cycle in a short period of time before the soil water is depleted (Figure 337). In contrast, riparian zone plants have a soil water supply longer than upland plants and stay green into the fall. This ability of plants to stay green longer in riparian zones promotes a habitat more suitable for foraging by large grazing animals. It is no wonder that in the absence of management, grazing animals may preferentially select riparian zones during dry, hot summer months and periods of drought. Due to the many values associated with riparian zones, grazing management is critical; however, the productivity of these sites makes them extremely resilient and suitable for proper grazing by livestock and wildlife. Figure 337 illustrates that riparian zone plants also may have a longer period to recover and regrow green biomass after foraging events. Although riparian zone grass-like plants generally grow to maturity about as fast as upland plants during spring, they have more soil water available to provide for regrowth after grazing. Because of their ability for regrowth, these plants provide a management advantage. Riparian zones and irrigated pastures can be used as a forage resource after upland plants

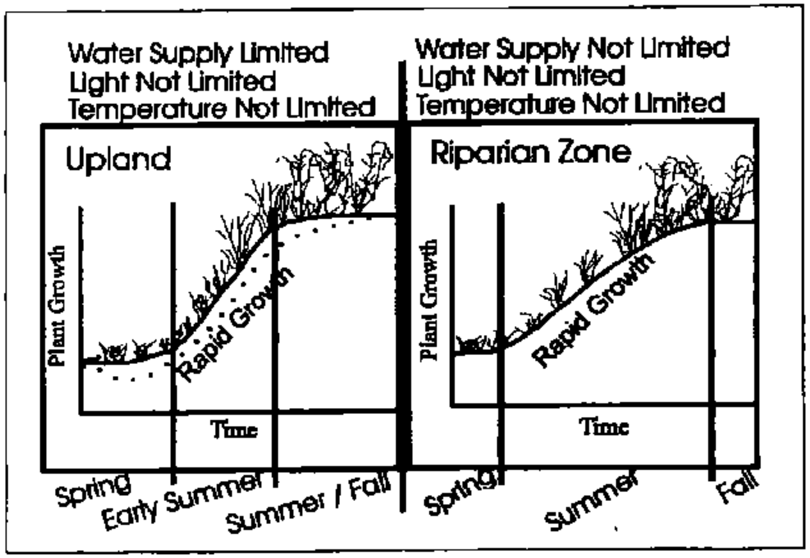


Figure 337. Generalized cumulative above ground biomass curves for comparing upland and riparian cool season grasses and the relative time a plant may have to regrow and stay green after being grazed.

have matured and during periods of drought. The question then becomes: How much and how often can riparian plants be grazed without permanently reducing the productivity, competitiveness, or habitat qualities of riparian plant communities?

A long-standing range management rule implies that if you graze half and leave half of the above ground biomass produced by a grass-like plant at maturity, grazing will not be detrimental to plant health. This rule was based on replacing nutrients to the root system (root mass lost when starting plant growth in spring would be replaced during the grazing season). Current research suggests the amount of photosynthetic material left after grazing, not the height of the plant, is the important factor when evaluating plant responses to grazing. The height of a grazed plant with sufficient photosynthetic material is probably much shorter than 50 percent of the total above ground biomass at maturity. This suggests that the "graze half, leave half" rule is conservative, so this guideline also should ensure that plants remain competitive. However, if plants are occasionally grazed shorter than the 50 percent rule, no permanent harm to the root system should occur based on our understanding of plant physiology.

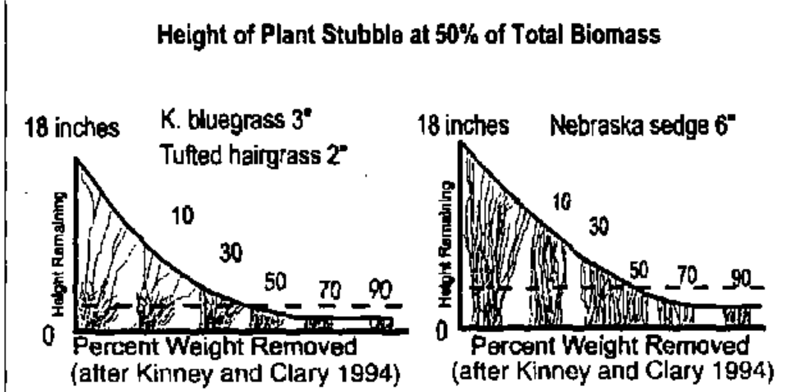


Figure 338. Illustrated height of remaining vegetation when 50 percent of the above ground total weight is removed for three 18-inch high grass-like cool season plants.

Assuming that the "insurance program" of using the 50 percent rule to maintain riparian zone plant health is accepted, then what does 50 percent look like? Not all grass-like plants growing in the riparian zone distribute their above ground biomass in the same way. In Figure 338, a 50 percent remaining biomass level of use has been shown by a dashed line to show how high different plants are when this level of grazing occurs on 18-inch plants. The tall sedge plant has a stubble height of 6 inches of remaining vegetation. Remaining tufted hairgrass and Kentucky bluegrass vegetation are about 2 inches high.

Figure 337 demonstrates that most of the above ground Kentucky bluegrass and tufted hairgrass biomass is concentrated in leaf material close to the ground surface. The above ground biomass of Nebraska sedge is, however, more evenly distributed along its full height. The difference in how riparian zones look after being grazed to 50 percent of their average total biomass, based on these three plant species, is going to be dramatic. Vegetation 2 inches high after grazing is often interpreted as 'heavily grazed" when, in fact, this level of grazing may be acceptable for grasses such as Kentucky bluegrass and tufted hairgrass. Therefore, consideration of plant growth form is important when developing a management strategy for controlled large animal grazing within riparian zones.

Kentucky bluegrass, tufted hairgrass, and Nebraska sedge are important riparian zone plants in Wyoming. These plants have been shown to be associated with different stages in channel succession (Figure 339). Therefore, when the areas in different stages of succession are grazed by large animals, grazing will appear more intensive in the grass zones than in the sedge zones when 50 percent use by weight occurs.

Riparian zones may be grazed by both wildlife and domestic livestock throughout the year. When the riparian zone is wet and just after snow melt, Kentucky bluegrass areas are green and the soil is firm enough to support grazing. Regrowth may occur on these sites, but the regrowth potential is not as great as it might be for *tufted hairgrass* or Nebraska sedge due to limited soil water in the area supporting Kentucky bluegrass. The soil water may be depleted earlier and limit regrowth in the Kentucky bluegrass zone, whereas soil water may be available to regrow the other two plant species. Nevertheless, Kentucky bluegrass sites often are subjected to several grazing events by different classes of animals, which may affect a manager's ability to meet resource objectives related to residual height of forage left after grazing.

GRAZING

Physical damage to channel areas, excess foraging on woody plants, and hummocking *impacts are concerns managers should* consider when planning a riparian zone grazing strategy. Vegetation, stabilizing sediment, and plant health concerns will most likely be addressed if these other impacts are minimized.

The U.S. Forest Service has provided three general guidelines to help manage large animals that graze riparian areas.

- Pay attention to the height of the most palatable grass-like plant species, and when the remaining vegetation height (residual height or stubble height) *approaches 3 inches, manage* the area in a focused way.
- Note when the stubble height of the grass-like plants moves *from 3 inches to less than 1* inch because this is when animals may move from foraging on grass to foraging on woody plants.
- Keep track of the greenness of the most palatable species, and when greenness diminishes and the plants appear to dry (*yellow and red*), *look for animals to seek greener vegetation*. This advice is excellent and will serve as a basis for the following discussion about riparian zone grazing.

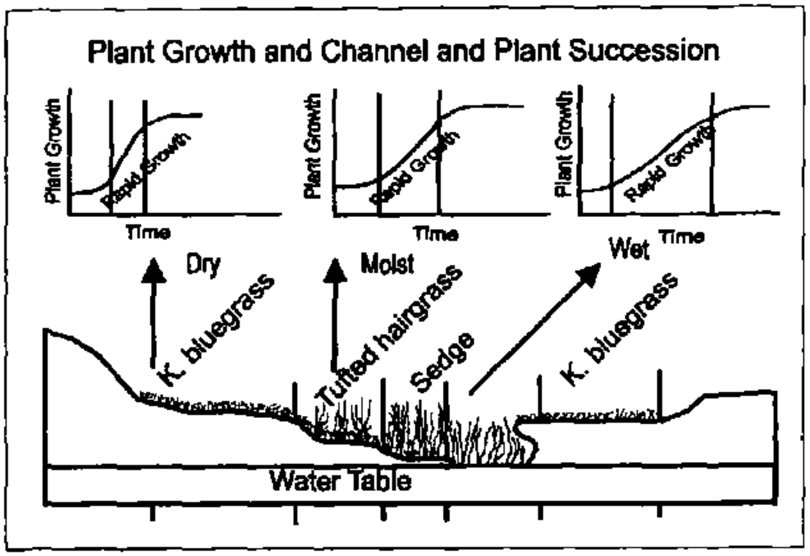


Figure 339. A generalized illustration of where Kentucky bluegrass and tufted hairgrass usually grow. Where they grow, one may expect short stubble height after grazing.

There appears to be two distinct locations in riparian zones where stubble height after grazing may warrant consideration. These areas or zones are the tall sedge and rush zone in wet areas and the *tufted hairgrass and Kentucky* bluegrass zones in the moist to dry areas. Therefore, in addition to what the U.S. Forest Service has provided above, stubble heights also may be used to predict the impact grazing activity may have on the physical integrity of riparian zone attributes and the potential preference to switch to woody plants.

Physical damage to riparian zones is likely when *soils are wet* and animals may break through the vegetation and soil surface to cause hoof damage, break off overhanging banks, and shear soils along channel banks and hummocks (Figures 310 to 318). Physical impact and grazing vulnerability of these wet areas may fluctuate *with season of the year and the amount* of precipitation received during any single season. Fluctuation is common because drainage, **evapotranspiration** (transpired water from plants and soil water evaporation), and drought cause the separate areas of channel and pond succession to dry at different times during the grazing season. The bluegrass zone dries and becomes firm first, the tufted hairgrass zone next, and the tall sedge zone last. To reduce physical damage to stream channels, choice of a grazing season must consider the kind of grazing animal. Control may be exercised by recognizing how stubble height is related to physical impacts by grazing animals.

Examples of where stubble height should be used to modify physical impacts to riparian zones are shown in relationship to the greenline concept, channel and vegetation stages in succession, and impacts illustrated in Figures 199 to 207, 214 to 222, 310 to 318, and 328 to 330. These figures suggest that remaining vegetation along a narrow band bordering the greenline of streams or ponds could be set at a designated height that would correspond to an acceptable amount of physical damage during grazing. This stubble height may or may not be higher than the height corresponding to the graze half and leave half rule. Stubble height also could be altered, depending on when animals are released to graze (**turn out dates**), precipitation during the growing season, and historical drainage patterns of individual wetland habitats.

In spring, green upland vegetation is present. This resource is available in addition to the green vegetation of riparian zones when soils of these areas are soft and wet. Domestic grazing animals often exhibit no preference for riparian zones during this period, and impacts to these areas are limited to physical impacts caused by livestock drinking water.

As stream banks, moist meadows, bogs, ponds, and lakes dry during late spring and summer, soils become firm and resist physical impact from grazing animals in the Kentucky bluegrass and tufted hairgrass zones. *Because 50 percent of the total plant production is* below 3 inches high, the goal of maintaining an average stubble height of 3 inches does not seem realistic. These dry and moist meadow riparian plant areas generally border the wet and tall sedge zone. Therefore, it is important to select a stubble height at the transition area between the moist and wet sedge zones that shows when hoof impacts are beginning to occur and when any further grazing would be unacceptable. This stubble height for tall sedges usually averages between 3 and 6 inches; however, to reduce hoof impact damage this height may have to be increased during late summer and wet conditions and could even be reduced in dry and drought conditions as illustrated in Figures 340 to 348.

Figures 340 and 341 are of the same area and represent use by wildlife in early June and by cattle in the middle of August. The area is very wet in June and plant regrowth, coupled with firmer banks, make this August photo more pleasing from a physical damage perspective. Figure 342 is before livestock grazing in the drought year of 1994, and Figure 343 is after grazing. The use of vegetation is relatively heavy but the stream banks were firm when cattle were given access to this forage base. Very little bank damage has occurred.

The stream and hummock area shown in Figures 344 and 345 were taken in the same grazing area as Figures 342 and 343 before and after cattle were placed and removed from this landscape. This represents the last of a drinking water supply so the cattle have to search for another drinking source. Some hummock hoof damage is present on the sides of mounds, but most mounds were too firm to suffer damage. Almost all of the tall sedges from hummock interspaces have been grazed below 2 inches.

Figure 346 was taken after cattle grazing in the drought year of 1994, and Figure 347 was taken after grazing and one year's rest in 1996. This adaptive management strategy, adopted by the rancher and the management agency, was designed to follow summer precipitation. In the drought year of 1994, hard soils in the riparian zone were *used to provide green forage. In the wet year of 1995, green forage* was used in lower elevation and privately owned pastures. The rancher did not necessarly need the mountain forage and because more tall sedge and hummock habitat had been used in 1994 than was desirable, rest from livestock grazing for a season was provided. During the 1996 grazing season when summer rains fell, greater than 6 inches of tall sedge were left in the wet riparian zone of Figure 347.

Figure 348 reminds managers that stubble height standards should remain flexible when used to regulate physical riparian zone damage caused by grazing animals. The hummocks in this photo clearly show that this wetland was dry and hard early in the grazing season and that grazing has only removed green forage. All hummocks and inter-spaces are covered with grass-like plants and bare ground caused by animal hoof action. This would not be the expected result if this area was grazed to a similar height when the soils were wet. If the soils in Figure 348 were wet it would be appropriate to use a tall sedge stubble height standard of 4 inches or more to minimize physical impacts to the hummocks and their inter-space area.

While physical grazing damage to stream banks and wet riparian areas can be reduced later in the summer, management is often faced with having mature upland vegetation that is turning yellow or red. At that point, land managers must carefully watch as the stubble height of the bluegrass and tufted hairgrass zones move from an average stubble height of 2 or 3 inches to less than 1 inch. Also, managers must observe foraging on the riparian zone's green woody plant species and any use on the transition zone between tall sedges and the moist and dry plant communities. Undesirable use levels of the woody plants can occur quickly and distributing animals to uplands becomes even more important to the manager.

It is in the best interest of the livestock manager to monitor impacts carefully during hot, summer months. This is true even when the upland vegetation is mature and the riparian zones are firm and hard. If monitoring does not happen, often the pasture is selectively grazed. Imposed use limits on specific riparian zone plant species (woody plants and tall sedges) may force an early retreat from the entire pasture system, even with ample upland forage.

Riparian zone grazing impacts are most often the result of improper distribution of animals, season of use, or length of grazing season. Because riparian zones are preferentially selected by grazing animals, adjustments in stocking rates are seldom effective in addressing management concerns. When riparian zones are used as key areas to assess grazing impacts for use of an entire pasture, intensive livestock management (i.e., herding) must be considered. Intensive management will prevent excessive use of the key area riparian zones, spread grazing to other rangeland resources, and increase the time livestock can graze the pasture. In essence, the manager must limit the time that animals stay in the green riparian zone when upland vegetation is maturing and turning yellow or red.

Much has been said about managing livestock; however, they are only one type of the many large animals that graze Wyoming watersheds. With the current interest in setting water quality standards and the call to evaluate impacts on private and public lands, it seems reasonable that all grazing animal impacts be evaluated to the same degree of scrutiny and accuracy by season of use, distribution patterns, and numbers.

Stream Flow Augmentation

Providing additional flow in excess of that which has historically been discharged through a stream or channel system may cause stored sediment erosion. This is especially true in steeper, smaller, headwater tributaries of a drainage basin and when geologic materials are not present to control and minimize down cutting original channel gradients. Sediment removed in these steep, headwater drainage basin segments is available for deposition in flat-gradient, larger channels downstream. Therefore, new bank and floodplains could develop within these larger channels where the historic flow regime did not flush deposited sediment downstream. One can expect the depth and width of the developing channel to adjust to the augmented flow or to a discharge with a new long-term average annual bankfull amount.

The prospect of having down cutting of headwater tributaries and channel filling of their larger receiving streams suggests that a change in channel gradient will occur with augmented flow. Therefore, before augmented flows are released, it is important to develop a plan to stabilize channel gradient. Small and incised streams are probably more susceptible to channel erosion caused by flow augmentation than are larger channels. Larger channels will usually have a wide and shallow channel that is controlled by periods of high flow from their numerous and smaller tributaries.

Increase in channel erosion caused by flow augmentation is related to how discharge fills a channel area. For example, adding a steady, annual discharge of 2 cubic feet per second (cfs) flow to a channel that formerly carried 50 cfs during high flow and 0 to 5 cfs during low flow is probably not going to add excessive stress to existing channel banks. This is not the case when 2 cfs are added to a channel that was developed to carry 0 to 2 cfs during low flow, and high flows can use the floodplain to dissipate energy and water. Adding 2 cfs fills the channel, and a full channel discharge will increase erosion. Therefore, potential for channel erosion increases when managers release augmented flow into the small and steeper tributaries of a drainage basin. An engineering approach to control channel gradient using structures in areas like these should be considered.

When managers have determined the need for placing in-stream structures to stabilize channel gradients, they should consider what may occur during high flow or extreme storm events. Structures are very vulnerable to high stream flow just after construction. A first level of protection is to establish vegetation that will provide added protection to disturbed areas around structures and construction areas. If the existing channel banks and floodplains do not support riparian plant species, then a plant selection, planting, and management plan should be established to include new riparian plant communities.

Augmented flow may provide a perennial water supply within an existing channel or to a channel during plant growth periods. This water supply will ensure riparian vegetation establishment. Timing planting in accordance with water availability may provide added protection against future high flows caused by storm events.

In channels or areas where riparian vegetation exists, protection against erosion from extreme storm flow events, in addition to that caused by the release of augmented flow, may require placing engineered structures into streams to control potential channel gradient changes. However, the presence of riparian vegetation, roots, and above ground biomass provides an excellent carpet to curb erosion from surface flow. Therefore, where a channel has not developed from augmented flow, the option to let flow seek and define its own channel can be considered (Figures 298 to 302).

Letting augmented flow define a channel will take time, but the surface augmented flow provides a saturated soil condition, promoting tall sedges and rushes that are often considered best for stabilizing channel banks. Once a channel is defined and flow is down cutting through the vegetation root zone, engineered in-stream structures may regulate flow and trap sediment so the channel bottom continues to maintain a high water table favoring growth of tall sedges. The in-stream structure height also may be lowered so that a lower water table level promotes the growth of riparian zone grasses in place of tall sedges and rushes.

In-stream structure design and construction in a channel where riparian vegetation occupies existing bank and floodplain areas can be used to stimulate progress in channel and plant succession. Where channels are large and wide enough to accommodate low flow and augmented flow without flowing against banks, in-stream structures can promote sediment deposition and encourage bank building to narrow the channel. In narrow and deep channels where low flow is in contact with both banks, in-stream structures may stabilize channel gradient before augmented flow is released. These structures should be designed to let sediment pass because deposition may accelerate the channel widening process.

In all cases, augmented flow release points must be stabilized when adding discharge to a channel or potential channel system. Channel gradient and in-stream structures can be a costly treatment for maintaining stream channel and riparian zone attributes. Therefore, vegetation management should be considered in the planning process. When structural and vegetation treatments are used together to stabilize channel areas, alternatives may exist to regulate low-flow water table levels along banks and under floodplains, so desired plant species can be established and maintained. But results of these treatments may be temporary. As new channel configurations become stable, the processes of channel and plant succession will occur.

WATER QUALITY

This text provides a basic understanding of Wyoming watersheds and how they function. Because the basic function of watershed streams is to remove sediment and water from their respective drainage basins, quality of the water that leaves the state will be different than its quality when it fell as precipitation. Before settlement, the sediment, chemistry, and biological components that made up Wyoming's water quality represented the natural (background) contaminant levels in stream flow. These historical pollutant levels are not well known, but some proportion of today's pollutant levels represent natural or background levels produced by inherent characteristics of individual watersheds.

The Wyoming Department of Environmental Quality (WDEQ) regulates water quality in the state, and it is their ultimate responsibility to maintain, improve, and protect water quality for the public. To regulate water quality, WDEQ must interpret information about how today's contaminant levels compare to natural or background pollution produced by landscape location and watershed conditions. This is essential because the U.S. Clean Water Act requires that individual states set Total Maximum Daily Load (TMDL) standards for all streams within their borders. WDEQ initiated the process of setting TMDL standards in 1998. They also began a monitoring program to measure pollution and assess stream health. The Wyoming Association of Conservation Districts (WACD) begen a formal program to measure water quality at about the same time. Therefore, two state organizations have committed to measuring water quality so that data collected can be used to help set Wyoming's future TMDL standards.

WDEQ has formed a TMDL Task Force consisting of representatives from throughout the state and across broad interests groups. The task force's purpose is to help guide WDEQ in setting future TMDL water quality standards. WDEQ also is advised by the Governor's Water and Waste Advisory Board, which reviews public input and WDEQ's proposed actions and offers advice. Decisions made by WDEQ and the advisory board are then submitted to the Wyoming Environmental Quality Council for additional public input and a final ruling on behalf of the state of Wyoming.

WACD has asked for and received help from the Wyoming legislature to train local people to sample and collect water quality data in a credible manner. The federal Natural Resource Conservation Service (NRCS) and University of Wyoming Cooperative Extension Service (UW CES), through the Department of Renewable Resources, made the commitment to conduct training on behalf of WACD and WDEQ. Materials presented in this book are being taught in UW CES workshops across Wyoming. Planning, sampling, and monitoring will be taught by trained NRCS and WACD personnel. Additional workshops to teach data analysis and interpretation are scheduled to begin the summer of 2000, organized by UW CES and WACD personnel.

The Wyoming Department of Agriculture has committed their expertise in Coordinated Resources Management (CRM) facilitation to obtain specific answers associated with the TMDL and other water quality issues. Because watersheds and stream flow do not recognize ownership and political boundaries, this commitment is important. An effective water quality assessment plan must be conducted at a watershed scale. The CRM process can be used to serve this purpose because it helps resolve differences of opinion between different groups. CRM may be employed to help develop unified and acceptable plans for managing watersheds and water quality.

The need and the infrastructure for obtaining a credible assessment of Wyoming's water quality has been established. WDEQ and WACD are now conducting water quality sampling programs to collect credible data and eventually set TMDL standards. However, these groups cannot be everywhere at all times of the year, and people and funding resources are limited. But working together, a basic water quality assessment can be realized for Wyoming.

A logical role for WACD is to assess water quality at the local level in a way that provides credible and meaningful data. Water quality tests selected to carry out WACD's water quality program should be:

- Simple and designed to obtain samples without difficulty and minimize cost
- Simple to analyze and producing results that address pertinent questions
- Repeatable, reliable, and with minimum bias

By following this procedure, data analysis can be efficient, and results will be meaningful for the people who are funding and conducting the sampling program. A quick turnover of results to funding and data collection personnel allows both to start the interpretation process, relating data to landscapes, user pressure, and watershed functions. WDEQ's responsibility should focus on complicated tests that have a long turnaround time between samples and need a high degree of expertise to interpret data. Simple testing carried out by WACD should help explain water quality differences found in the more intensive testing by WDEQ.

Based on watershed functions presented in this text, water quality should not be the same for all Wyoming streams; therefore, future TMDL standards also should not be the same. A uniform standard will have no credibility. The public deserves clean water and an honest assessment protocol. As WDEQ and WACD go forward with their respective sampling programs, they may consider evaluating their monitoring program on the following criteria:

- Be simple and reduce the time and cost of collecting data
- Define common sampling points that produce data to detect change in water quality caused by user pressure versus contributions that exist from the basic watershed functions
- Agree on specific sites, tests, and testing protocol to increase sample numbers and reduce cost during any particular season or storm event and that can be related to local landscape and watershed issues
- Provide a basis to allocate sampling responsibilities between the two parties and, then, accept who will be responsible for conducting and analyzing specific water quality samples

Summary of Management Concerns

Wyoming is fortunate to have state and local efforts focused on assessing water quality. To maintain this effort for any length of time, other organizations must continue to provide support where needed. CRM facilitation, teaching by UW CES, and the advice and planning of NRCS must continue. WDEQ recognized this need when the TMDL standards issue surfaced. Coordinated education, public participation, and focused communication is being nurtured by WDEQ and WACD. Water quality sampling programs are in progress and should be evaluated to ensure the sampling program is providing meaningful data that is relevant to the questions being asked. WDEQ and WACD also might consider reducing the overlap of sampling sites and responsibilities and the need to conduct expensive and time-consuming testing where other simple and routine procedures can be used to answer the same questions. Success of this program will depend upon strong relationships and trust between local, state, and federal authorities for conducting water quality assessments.

Augmented flow to drainage basin stream channels may accelerate erosion and reduce the quality of Wyoming's water resources. To reduce the accelerated erosion potential, the point and stream where augmented flow is released must be stabilized with an engineered treatment and vegetation. Once augmented flow is released to a channel system, or potential channel system, engineered structures may be necessary to maintain a desired stream gradient so that down cutting does not occur. Steep, confined, small stream channels located in the headwaters of larger drainage basins are more susceptible to down cutting. The wider and larger channels on flat landscapes, which receive flow and sediment from the smaller tributaries of their respective drainage basins, may fill and develop narrow and deeper channels.

Control of channel down cutting and filling using engineered structures should include a vegetation management plan for areas around each structure and along the stream between them. If augmented flow is to be provided on a perennial basis, the vegetation management plan should focus on using desired riparian zone plants to mitigate channel bank erosion and protect floodplains during periods of flood flow caused by extreme storm events. Engineered structures that encourage riparian plant growth in both early stages of channel succession (when channel filling is encouraged) and later stages in channel succession (when channel down cutting is expected to occur) should be used. As channels stabilize in response to augmented flow, riparian plant species will likely change in response to the soil water regime as channels go through various stages of succession.

Riparian zone grazing by large animals may physically impact channel banks and moist and wet areas around bogs, springs, ponds, and lakes by hoof action. Physical impacts may alter water quality and sediment loading. Large animal impacts are generally greater in wet soils than in moist and dry soils. Livestock impacts may be reduced by grazing when upland vegetation is green and allowing animals to spend limited time in riparian zones. When upland vegetation matures and turns yellow or red, livestock grazing impacts can be reduced by drifting animals to uplands on a routine basis. Although late season use is the best time to graze riparian zones because soils are relatively dry and firm, animals may shift their preference to woody plants and the tall sedge communities in wet areas. To control physical impacts and excessive use on woody species, remaining vegetation or stubble height limits may be used to determine when to move livestock to other pasture systems.

Most large grazing animals exhibit preferential selection for riparian zones and have the potential to impact channel banks and riparian zone woody plants. The influence of all large ungulates on water quality and riparian zone habitat should be considered by the managers responsible for meeting water quality standards and protecting the public's water and land resources.

In Chapter 6, monitoring will be addressed in a context that should relate to landowners and the public. The issues of grazing riparian zones, setting TMDL standards, and changing or altering discharge in Wyoming streams and rivers are all complex and controversial issues. Natural resource managers should base their watershed and management strategies on credible data and not preconceived notions or uninformed public opinion. However, because natural resource managers are in short supply and public policy changes so rapidly, landowners now may need to justify their use of these resources by collecting their own credible data. In support of this argument, it seems reasonable to suggest that all watershed users collect data in the same way to ensure the sustainable use of Wyoming landscapes and watersheds.

Invasive Plant Management: CIPM Online Textbook

Chapter 3: Plant Invasion and Succession

Roger L. Sheley, USDA/ARS

Introduction

World agriculture is striving toward a future that provides nourishing food, protects those who work the land, helps stabilize the earth's climate, and safeguards our soil and water. Many rangeland managers and owners have focused weed management efforts on simply controlling weeds, with limited regard to the existing or resulting plant community. Because of environmental, ecological and economical concerns, the appropriateness and effectiveness of rangeland weed management practices are being questioned. It has become clear that weed management decisions must consider these concerns. The development of future weed management practices must be based on our understanding of the biology and ecology of rangeland ecosystems. We believe weed management education should focus on providing land managers the principles and concepts on which to base their decisions, rather than just providing prescriptions for weed control.

Land use objectives must be developed before rangeland weed management plans can be designed. This implies that strictly killing weeds is an inadequate objective, especially for large-scale infestations. However, a generalized objective could be to develop a healthy plant community that is relatively weed resistant, while meeting other land-use objectives, such as forage production, wildlife habitat development, or recreational land maintenance.

A healthy, weed-resistant plant community consists of a diverse group of species that occupy most of the niches. Diverse communities capture a large proportion of the resources in the system that preempts their use by weeds.

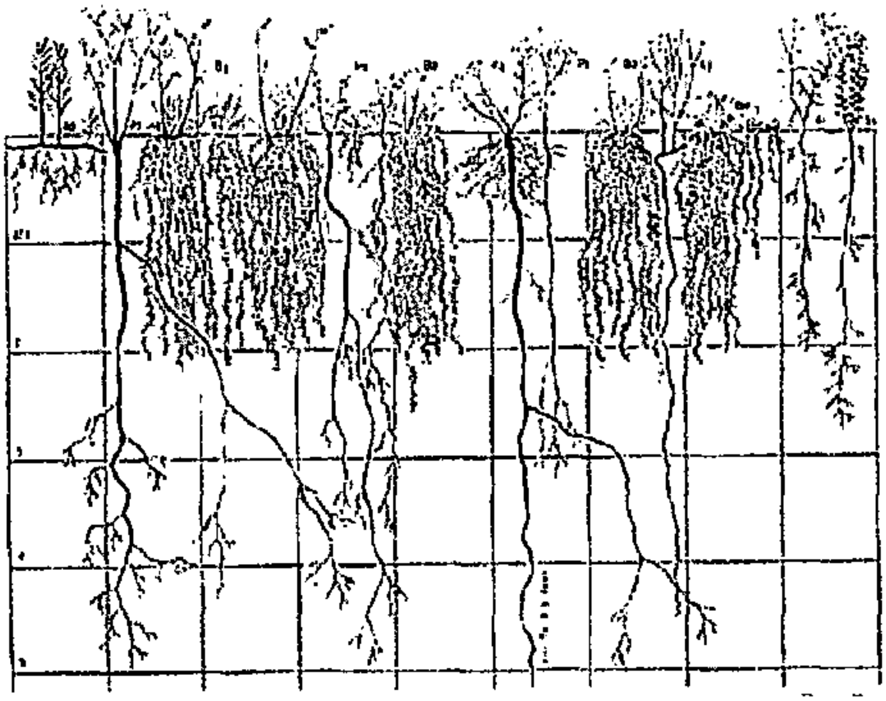


Figure 3-1. *Root development of native prairie plants in the shortgrass mixed prairie at Hays, Kansas, a the end of the Dustbowl. Weaver, J.E. and F.W. Albertson. 1943. Resurvey at end of the great drought. Ecological Monographs (13)1. A. Cuman ragweed B. Slender scurfpea C. Blue grama D. Red false mallow E. Buffalo grass F. False boneset G. Rush skeletonplant H. Narrowleaf fouro'clock I. Lacey tansaster.*

Weed-resistant plant communities effectively use resources over time and space. These communities may include an early emerging species, such as the shallow-rooted Sandberg's bluegrass (*Poa sandbergii* Vasey), which uses the resources that are available in the upper soil profile early in the growing season and during periods of light precipitation. As the season progresses, species which initiate growth later, but continue growth later into the season are needed to use available soil resource from moderate soil depths. Finally, the diverse plant community may include a deep taprooted, very late maturing species, such as alfalfa (*Medicago sativa* L.) or big sagebrush (*Artemisia tridentata* Nutt.). These species are capable of extracting resources from deep in the soil profile and throughout much of the growing season.

Although little is known about the role of many species within the plant community, it has been propose that maximum diversity provides for stability and resource capture over a wide range of unpredictable conditions. This is not to imply that diversity guarantees weed-resistance, or that some virtual monocultures would not resist weed invasions. Once the desired plant community has been determine an ecologically based weed management system may be developed. The ecological and economic impacts of invasive species are felt from the local to the global scale. Scientists, land managers, and th general public are becoming more aware of invasive plant impacts. Weed invasion is considered the second most serious threat to natural habitats, after habitat fragmentation and loss (Randall 1996). The economies of many states are based upon use or extraction of natural resources for food and economi growth. Utilization of resources has been impacted by the encroachment of invasive plants. Selected studies have documented the impact of individual species. For example,

- Spotted knapweed costs the state of Montana an estimated $42 million annually (Montana Weed Management Taskforce, 2001).
- It is estimated that tansy ragwort invasion has caused losses of $6 million per year to the state of Oregon (Radtke and Davis, 2000).
- Leitch et. al. (1996), estimated a $42 million annual loss due to 3 Centaurea species in Montana, N Dakota, South Dakota.

As scary as some of these numbers sound, comprehensive data about economic impacts are scarce, and it is even more daunting to assess economic and ecological costs for invasive plant species in a meaningful way. Cost benefit analysis reflecting the true costs associated with invasive plant invasion have been completed for few species at varying scales using different methodologies. The extent of economic damage caused by invasive species is only beginning to be appreciated by economists and policy makers, and the methods by which to do so are still being explored or have not been tested at th landscape scale.

- Hybridization between native cordgrass Spartina alterniflora and an exotic cordgrass Spartina folisa have created a fast growing plant with rhizomatous roots which accentuates tidal sediment build up and has decreased habitat for shorebirds and waterfowl in the San Francisco Bay (Vila et. al., 200C
- Melaleuca invades wetland areas in Florida and creates monospecific stands. Increased shade anc soil temperature changes the local microclimate, the water table is lower, and fire frequency and intensity are altered. (Randall, 1996).
- A significant reduction in the five most common native species was recorded in native mixed grass prairie invaded with leafy spurge Euphorbia esula. (Belcher and Wilson, 1989)
- Invasive pathogens from Europe essentially eliminated the once dominant American chestnut and American elm trees (Mooney and Hobbs, 2000)

Plant invasions have been shown to alter ecosystem processes, like nutrient cycling, fire frequency, hydrologic cycles, sediment deposition and erosion. Invasive plants displace native species or hybridize with them, altering the gene pool. Yet, ecological impact is perhaps even more difficult to assess than the economic effect. Putting a price on "ecosystem services", or those benefits supplied to human societies by natural ecosystems, is complex. Such benefits include timber, game animals and pharmaceutical products, items that we have traditionally assigned an economic value, and can "price". Ecosystem services, such as purification of air and water, climate regulation, regeneration of soil fertility decomposition of wastes, maintenance of biological diversity are more complex, and it becomes more difficult to assign value. The natural processes that occur within systems like the nitrogen cycle, carbon cycle, etc. are largely not accounted for when trying to assess the cost of ecological impact, how to assess the values as well as how to assign value to ecological assets is an issue that economists, ecologists, and policymakers are facing.

This chapter is written to synthesize the current state of the knowledge for both economic and ecologic impacts caused by exotic plant invasion. As information is collected and synthesized, the chapter will b updated. To date, an initial literature review has been completed. A synthesis of the current literature w be posted and research directions assessed.

Functional Groups: Understanding Healthy, Weed-Resistant Plant Communities

An objective of sustainable invasive plant management is to develop ecologically healthy plant communities that are relatively weed-resistant while meeting other land use objectives such as forage production, wildlife habitat development, or recreational land maintenance (Sheley et al. 1996). A healthy, weed-resistant plant community consists of diverse species that occupy a majority of the niche in the plant community. (Carpinelli 2001, Jacobs et al. 1999). Weed-resistant plant communities effectively use resources over time and space, closing niches to invading nonindigenous plants (Robinson et al. 1995, Sheley et al. 1996). Enhancing the diversity of indigenous functional groups may preempt resources, thus making resources less available to invasive species.

Mechanisms of Invasion

Susceptibility of plant communities to invasion may be influenced by many factors including community structure (Orains 1984), resource availability (Burke and Grime 1996, Elton 1958, Stohlgren et al. 1999 Tilman 1997), and invader traits (Davis and Pelsor 2001). Most nonindigenous plants invade latitudes similar to their native occurrences; however, invaders' function may be fundamentally different from the local vegetation (Callaway and Aschehoug 2000, Rejmanek 1996, Rejmanek and Richardson 1996). Nonindigenous species also may have genetic and life history traits that allow them to preempt resources more rapidly than indigenous vegetation, allowing them to become successful invaders (LeJeune and Seastedt 2001, Rejmanek 1996, Roy 1990, Sakai et al. 2001).

Myers (1981) found that in the foothills of southwestern Montana, the frequency of hot-season use from July 10 to September 1 (period of heavy use) appeared to be a critical factor in developing and maintaining satisfactory riparian area conditions. Grazing systems with hot-season use in more than 1 year out of 3 or 4 met riparian habitat goals on only 24 percent of 21 streams. Grazing systems lacking hot-season use, or with no more than one hot-season treatment in 3 or 4 years, met riparian habitat management goals on 90 percent of 20 streams evaluated. Utilization data were not available in this study.

Myers (1989a) also analyzed duration of hot-season (7/1-9/15) grazing treatments and found that successful treatments averaged only 12.5 days, whereas unsuccessful treatments averaged 33.4 days. In this case, utilization of willows was important. However, duration was important from the standpoint of physical damage, regardless of utilization or regrowth potential, because of more frequent watering requirements and preference for shade while loafing. Duration of successful grazing treatments varied greatly depending on vegetation and stream type.

7. Deferment Until the Late Season (Fall Grazing)

Deferment is the postponement or delay of grazing to achieve a specific management objective (Forage and Grazing Terminology Committee 1991). Skovlin (1984) suggests that deferring use until the late season, until restoration of habitat is acceptable, offers a good measure of protection without great expense.

In fall, warm-season plants stop growing. Some cool-season species may grow where moisture and temperatures allow. Fall use is usually less critical than summer use because many perennial plants are completing their storage of carbohydrates and no longer need active leaf area. Upland cool-season species may again produce palatable forage, which, together with cooler temperatures, shifts livestock use to the uplands and relieves grazing pressure in riparian areas.

While livestock are often assumed to be leaving riparian areas to use upland range, that may not always be the case. On one study site in a long glaciated U-shaped valley in Idaho, Platts and Raleigh (1984) found that a late grazing system helped restore riparian quality because livestock moved to the uplands in late summer and fall when a cold air pocket formed over the bottomlands. However, at another study site in a flat, broad valley 15 miles away, livestock were drawn to the riparian areas during late season because those areas contained the only remaining succulent vegetation.

Heavy fall riparian use can leave streamside vegetation depleted and banks vulnerable to damage during spring runoff. Streambank damage relates to many factors, including soil moisture content, soil type, absence of woody plants and root systems, bank rock content, stock density, availability of off-stream water, and duration of grazing. Streambank damage due to livestock trampling of wet soils, and where other factors are not controlling, may be avoided by deferring grazing until bank soil moisture content is less than 10 percent. This usually occurs by late July or early August in most of the arid and semiarid western range (Marlow and Pogacnik 1985).

Deferring grazing until after seedripe can benefit sedge/grass communities if sufficient regrowth (or residual vegetation) protects banks and retains sediment during the next high-flow event (Elmore and Kauffman 1994). Furthermore, woody species utilization must be carefully monitored because use often begins during the later part of the hot season when livestock tend to concentrate in riparian areas. Levels of utilization that maintain the diversity and productivity of meadow communities were found to retard woody plant succession on gravel bars (Green 1991). Kovalchik and Elmore (1991) noted that systems with late-season grazing are incompatible with willow management.

On the Smiths Fork Allotment in the Kemmerer Resource Area of the Rock Springs District in Wyoming, deferred grazing, together with good herding and salting practices, resulted in improved riparian and fish habitat in the Huff Creek drainage. Prior to treatment, Huff Creek was in a deteriorated state. It had changed from a cold-water fishery in good condition to a warm waterway with severe streambank erosion and excessive siltation. Willows had been replaced by sagebrush (Smith pers. comm.). During 1976 to 1979, in order to protect and enhance habitat for the rare Bear river cutthroat trout population, two exclosures were built, instream habitat improvement structures were added to one exclosure, and deferred grazing was initiated outside the exclosures (Figures 13 and 14). Livestock use in Huff Creek was limited to August 15 to September 30 each year. The range rider salted the ridges away from water and kept the 500 livestock distributed over the entire watershed. Livestock were moved away from the stream every 2 to 3 days, thus reducing impacts in the riparian area (Netherly and Hendersen pers. comm.).

The Wyoming Game and Fish Department monitored Huff Creek during 1978 to 1984 (Binns and Remmick 1986). As a result of the treatments and management applied in Huff Creek, trout habitat improved at all study stations inside and outside the

Figure 13. Riparian conditions in grazed area on Huff Creek below lower enclosure, July 1986.

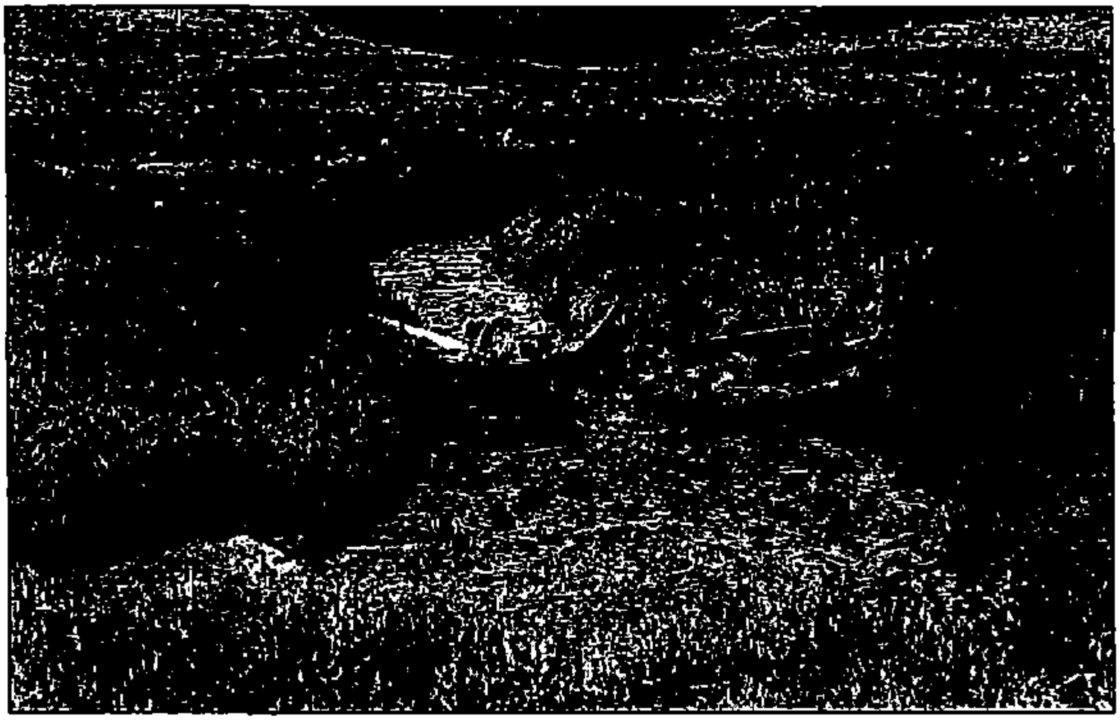


Figure 14. Looking upstream into lower Huff Creek exclosure from grazed area, July 1986.

exclosures by 57 percent. Trout cover increased 214 percent. Bank stability improved except inside the small exclosure. Trout 6 inches and larger increased 300 percent in one exclosure, 92 percent in the other exclosure, and 72 percent in the grazed area. Field personnel credited the local grazing association's and range rider's control of the livestock as the key to riparian area improvement outside the exclosures.

8. Deferred and Rotational Deferred Grazing

Deferred grazing is a nonsystematic rotation with other land units, and rotational deferred grazing is the systematic rotation among land areas within a grazing management unit (Forage and Grazing Terminology Committee 1991). Both strategies have been successful in restoring and improving riparian areas. Deferred and rotational deferred grazing strategies are often combined with rotational stocking (rest-rotation). The common thread of successful application, except for riparian pastures used in a deferred strategy, has been to use many pastures to shorten duration of use and provide greater flexibility. Many riparian grazing successes in Montana use seven pastures or more (up to 38) (Massman ed. 1995). Masters et al. (1996b) concluded, "Four-pasture, five-pasture (or more) rotation schemes with no rested pasture may be more suitable to areas that require increased streambank vegetation. The additional pastures or smaller riparian pastures allow for a shorter grazing season and greater flexibility in rotation schedules."

One common problem in multiple-pasture systems is allowing livestock to drift between pastures rather than moving them in a timely fashion. In his evaluation of 30 grazing systems on 44 stream reaches in Montana, Myers (1981) concluded that livestock should be moved between pastures rather than left to drift over a period of several days. In this analysis, riparian vegetative response seemed to be better in allotments where the livestock were moved and the gates closed, as opposed to the use of livestock drift and simultaneous use of two pastures. Other field personnel also emphasize the need to move livestock and not expect drift to accomplish the desired movement. Some livestock will stay in a pasture eating regrowth even though there is adequate palatable forage in the next pasture. One recommended approach, which can minimize livestock stress and encourage better dispersal, is to open the gate in late afternoon of day one, allow drift on day two, and clean the pasture and close the gate on day three (Hagener pers. comm.).

Based on research at the Red Bluff Research Ranch near Norris, Montana, Marlow (1985) suggests a grazing system based on seasonal preference for riparian and upland forage. In this area, livestock spend most of their time during June and July in the uplands, moving to the riparian sites in late July where they graze until October. Bank trampling damage is reduced by deferring grazing until after late July when soil moisture content had decreased to 8 to 10 percent or less. This system requires a minimum of three pastures and uses a 3-year cycle. Stocking rates in the pasture used first are based on forage available on both the upland and riparian sites. Stocking rates on the two pastures used later are based on 20 to 30 percent utilization of forage on only the riparian sites. Although this may appear to drastically limit the length of time a pasture can be used, riparian zones usually produce three to four times the forage of upland areas. The regrowth potential of riparian species is great enough that, during most years, regrazing of the same pasture can occur at 30- to 40-day intervals until frost. Consequently, there is little, if any, change in the amount of forage a rancher has available to his livestock in the grazing season. Once the target level of use is reached, livestock are moved to the next pasture. Each pasture receives 2 years of deferment during periods when soil moisture exceeds 10 percent (June-July). The pasture used early the first year is grazed progressively later during the second and third years.

Using riparian habitat as a key management area in conjunction with a deferred rotation grazing system has improved riparian area conditions on the Little Sandy Allotment in the Green River Resource Area of the Rock Springs District. This success is the result of sufficient flexibility, use supervision, and cooperation by permittees and the Wyoming Game and Fish Department. The sagebrush and grassland allotment is grazed by 2,500 cattle from May 1 to November 15 using five pastures, with riparian areas in each pasture. Herding and drift fencing control livestock movement from lower to higher range. Pasture moves are made so as to prevent adverse impacts in the riparian areas, avoiding bank trampling damage and excessive utilization. Sixty percent utilization of key herbaceous vegetation in riparian areas is used as a general rule to prompt pasture moves. One of the two lower pastures is always used first each spring due to elevational effects on range readiness, and the other is used last in the fall. Livestock graze the middle pasture twice per season going to and coming from the upper part of the allotment. They alternately graze the upper two pastures after seedripe each year.

This management system has been in effect since 1980. Prior to that, bank trampling damage was evident, much of the streambanks lacked protective cover, plant vigor was poor, willow reproduction was very limited, and wildlife habitat was nonproductive (Smith pers. comm.). After 16 years, conditions are much improved (Figures 15 and 16). Willow reproduction is apparent, banks are stabilized, plant vigor is improved, and the fish, beaver, moose, and duck habitat is productive again (Krosting and Christensen pers. comm.).

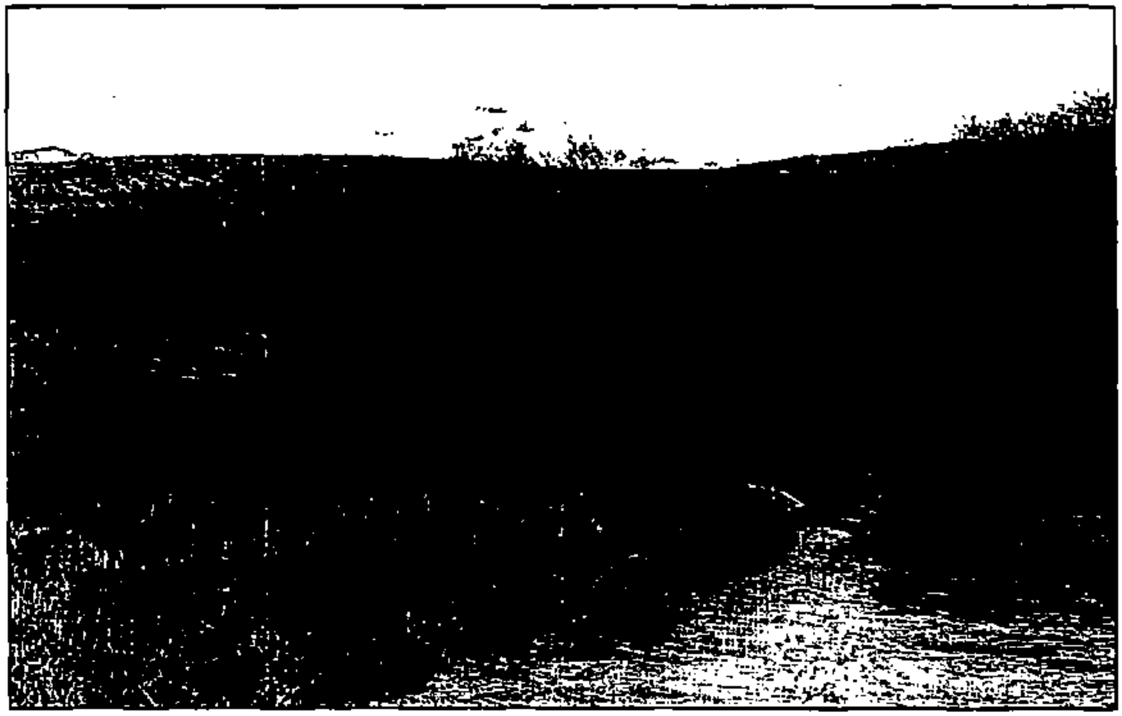


Figure 15. Riparian conditions on Little Sandy River in Little Sandy Allotment following July grazing treatment, 1986.

Figure 16. Riparian conditions on Lander Creek in Little Sandy Allotment, July 1986.

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Thomas E. Bedell
Certified Range Management Consultant
Philmoth, Oregon
John C. Buckhouse
Department of Rangeland Resources
Oregon State University
Corvallis, Oregon
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1839 York Street
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Grazing Management for Riparian-Wetland AreasSteve Leonard
Riparian Ecologist/Grazing Management Specialist
National riparian Service Team
Prineville, Oregon
Gene Kinch
District Manger (Retired)
Bureau of Land Management
Rock Springs, Wyoming
Van Elsbernd
Rangeland Management Specialist
Forest Service
Ft. Collins, Colorado
Dr. Mike Borman
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